Available online at www.elixirpublishers.com (Elixir International Journal)

Energy and Environment

Elixir Energy & Environment 63 (2013) 18358-18362

ISSN: 2229-712X

Physico-Chemical and Heavy Metal Status of Water Samples from Selected Hand-dug Wells at Auto-mechanic Workshop in Ado- Ekiti, South Western, Nigeria

Olayinka Abidemi Ibigbami* and Sulaiman Adeoye Olagboye

Department of Chemistry, Ekiti State University, P.M.B. 5363, Ado – Ekiti, Nigeria.

ARTICLE INFO

Article history:

Received: 29 August 2013;

Received in revised form:

29 September 2013;

Accepted: 4 October 2013;

Keywords

Physico-chemical,

Maximum permissible,

Underground,

Water.

ABSTRACT

The study considered the impact of auto- mechanic activity on underground well water in Ado- Ekiti. Physico-chemical and heavy metal status were determined in water samples from four auto-mechanic workshops and control site in Ado- Ekiti. Samples were collected for both dry and wet season. The results showed that pH for both season ranged from 5.92 - 7.89, temperature (21.0 - 28.0^0 C), conductivity (232 - 456 µms/cm), dissolved oxygen DO (3.98 - 5.19 mg/L), chemical oxygen demand COD (10.1 - 14.4 mg/L), Turbidity (12.8 - 30.4 NTU), sulphate (5.17 - 9.05 mg/L), total hardness (160 - 360 mg/L), suspended solids (62.0 - 142 mg/L), total solids TS (100 - 480 mg/L), total dissolved solids (200 - 420 mg/L), chloride (78.1 - 208 mg/L), alkalinity (12.1 - 26.5 mg/L $CaCO_3$) and acidity (0.16 - 0.28 mg/L $CaCO_3$). The turbidity levels in all the samples were high when compared with maximum permissible level while most of the physio-chemical parameters fall within the WHO standard for drinking water. Zn, Cr, Pb , Cd, Cu and Fe concentration for both season ranged from 0.8095 - 1.3921, 0.0002 - 0.0009, 0.0014 - 0.0036, 0.0016 - 0.0136, 0.9099 - 1.8552 and 0.1862 - 09.4623 mg/L, respectively. Cadmium was slightly higher than maximum permissible level for drinking water when compared with WHO standard. On pair wise comparison using linear correlation r_{xy} at $P_{0.05}$ n-2=4, there were significant difference in the concentration of heavy metals and the control samples for both seasons. The result also showed that at $P_{0.05}$ n-2=12, the physico- chemical parameters for both dry and wet seasons for the four wells were significantly different when compared with control samples.

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Introduction

Auto- mechanic activities usually produce comparable amount of pollutants due to their intensive operations (Sax, 2001). Ekong et al. (2012) asserted that less attention has been paid to pollution caused by the maintenance dimension of automobile transportation (auto- mechanic activities).

Most mechanic workshops in Nigeria are usually located around residential homes. Some personally dig hand wells for the purpose of mechanic activities. Activities such as discharging dirty engine oil on the ground, pouring of petrol, diesel, engine oil and electrolyte on the ground, washing dirt from roofs and bogged vehicles on the ground and contaminated wash water containing hydrocarbons, acids, soaps and other chemicals pour on the soil could greatly affect the soil and underground water quality. The importance of water quality to human life cannot be over emphasized. Keating (1994) reported that in developing countries an estimated 80% of all diseases and over one third of deaths are caused by consuming contaminated water.

Several persons had reported the impact of mechanic activities on soil and water in Nigeria. Port- Harcourt (Iwegbue, 2007), Akure (Ilemobayo and Kolade, 2008), Iwo (Ipeaiyeda and Dawodu, 2008) and Ibadan (Adelekan and Abegunde, 2011).

In monitoring water quality parameters in well water from these mechanic workshops, the research aim in assessing the physio-chemical and heavy metal status of well water collected at auto- mechanic workshop in Ado – Ekiti.

Materials and methods

Study Area

Ado – Ekiti (7^0 31^1 N and 7^0 49^1 N) is located in South western part of Nigeria. Ado – Ekiti showed seasonal variation in the pattern of rainfall. The mean annual rainfall and temperature is about 1, 367mm and 28^0 C. Rain normally falls between April and October while the dry season is between November and March. The Vegetation consists mainly of grassland, shrubs and tall trees interspersed with grass cover. Public services, trading and farming constitute the main economic activities of the people. The food crops grown are maize, cassava, yam, rice and plantain while cocoa and oil palm are the major cash crop of the people.

Sample Collection

Water samples were collected from four different hand-dug wells within the premises of auto-mechanic workshop in Ado-Ekiti (Dallimore, Ajilosun, Odo-Ado and Adebayo). Water samples were collected seasonal. For dry season, samples were collected in December while samples for rainy seasons were collected in June. Control samples were collected from hand-dug well that are not suited within the premises of auto-mechanic workshop.

All the glassware and plastics bottles used in this work were washed with detergent solutions, rinsed with distilled water and soaked in 10% HNO_3 for three days and rinsed twice with

Tele:

E-mail addresses: olayinkaibigbami@yahoo.co.uk

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distilled water. The pH, temperature and conductivity were determined directly from the sampling site.

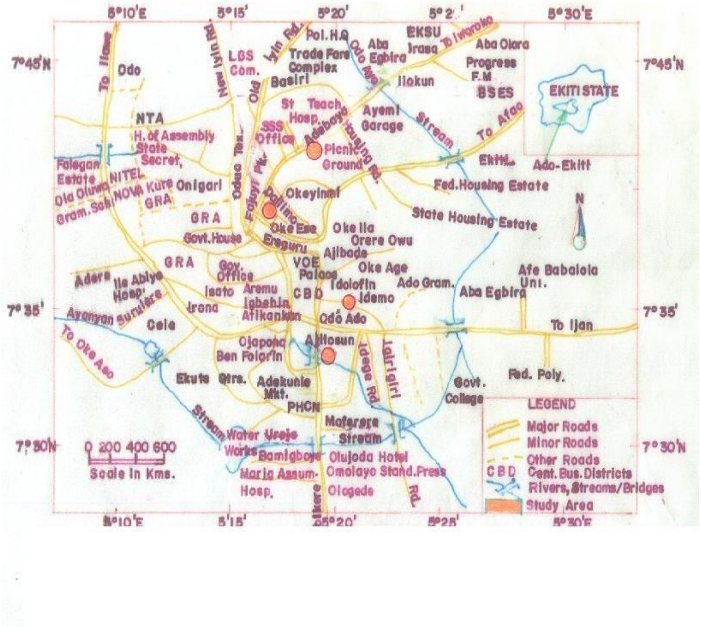

Fig. 1: Ado-ekiti in map showing adebayo, ajilosun, dallimore and odo-ado streets as sampling locations

Source: Ado- Local Government secretariat, Ado – Ekiti / Dept. of Geography & Planning Science, Cartographic Unit, Ekiti State University, Ado – Ekiti.

Sample Treatment.

The pH, temperature and conductivity of the water samples were determined on the spot using a calibrated pH meter, thermometer and conductometer Hach model 4600 and TDS meter. Various standard methods (APHA, 1998) were used for the determination of other parameters.

Heavy metals in the sample were determined by digesting 100ml of the water sample with 10ml HNO_3. Glass watch was placed on top at the digestion vessel to minimize evaporation and vessel was heated in a water bath between 90 – 100^{0}C for 2 hours.

Results and Discussion

Physico-chemical characteristics of the water samples

The physico-chemical parameters obtained from seasonal analysis of water samples from four different mechanic workshops in Ado – Ekiti were shown in table 1 and 2 respectively. The results showed that the pH values during the dry season ranged from 5.92 – 6.87 with an average value of 6.25 ± 0.42 while rainy season showed that the pH ranged of 7.00 - 7.89 with average value of 7.44 ± 0.38. The pH is a measure of effective concentration (activity) of hydrogen ion in water. Water samples collected in Ajilosun, Dallimore, and Adebayo during the dry season showed a low pH when compared with Odo –Ado. The pH of the samples collected during the dry season was within the recommended range (6.5 – 9.5) as stipulated by WHO. The pH range obtained in this study is also similar to what Adeyeye and Abulude (2004) reported (5.90 - 7.60) when studying the assessment of some surface and ground water sources in Ile – Ife, Nigeria.

The low values of pH recorded during the dry season in water samples collected in Adebayo, Dallimore and Ajilosun might be as a result of the auto-mechanic activity in these area, as fuel which contain organic compound tends to leach into the underground water while partial decomposition of organic matter by bacteria and fungi has been reported to produce various organic acids that are capable of lowering the pH of aqeous solution (Asaolu, 1998).

Temperature controls the solubility of gases in water, the reaction rate of chemicals and toxicity of ammonia. For dry season, the temperature ranged from 26.0 – 28.0 ^{0}C with an average value of 26.8 ± 0.97 while for rainy seasons, it ranged from 21.0 - 24.0 ^{0}C. It was observed that the temperature of the water samples during the dry season were generally higher than the ones collected during the rainy season. The relatively high variation in temperature of the samples could be as a result of climatic condition, time of collection and depths at the wells. The results obtained in this study for temperature is similar to what Asaolu (1999) reported when studying the physicochemical parameters of coastal water of Ondo – State and Adefemi *et al*. (2007) when assessing the physicochemical status of water samples from major dams in Ekiti State.

The Electrical conductivity ranged from 317 – 440 µms/cm during the dry season, while for rainy season it ranged from 232- 456 µms/cm. Comparing these values with WHO recommended values for conductivity (400 µms/cm), water samples collected in Odo – Ado and Adebayo during the dry season and Ajilosun during the rainy season showed values higher than minimum acceptable levels as stipulated by WHO. These showed that these water samples contain considerable level of dissolved ions.

The DO level varies in all the samples collected. The solubility of oxygen in water depends upon water temperature, the partial pressure of oxygen in the atmosphere, and salt content of the water. The DO concentration ranged from 3.98 - 5.19 mg/L during the dry season, while the rainy season ranged from 4.05 – 4.72 mg/L. The standard for sustaining aquatic life is stipulated to be 5mg/L (Home and Goldman, 1994). The result obtained for DO during the rainy season showed no significant different in all the samples. The DO concentration in water samples from Odo – Ado and Adebayo during the dry season showed greater values when compared with the DO concentration standard for sustaining aquatic life.

The chemical oxygen demand (COD) is a measure of the oxygen equivalent of the organic matter in a sample that is susceptible to oxidation by a strong oxidizing agent. COD values can also be used to characterize the degree of pollution and self purification of water. The COD concentration ranged from 10.1 – 13.2 mg/L in samples collected during the dry season while rainy season concentration ranged from 10.9 -14.4 mg/L. Critical look at the results reveal that, values of COD in Dallimore during the dry and rainy season showed the least value for COD concentration, this showed that Dallimore samples contain the least organic matter that can be chemically oxidized. The SS, TS and TDS concentration in the samples collected during the dry and rainy season ranged from 62 - 100, 290 - 360, 200 - 300 mg/L and 80 - 142, 420 - 480 and 300 - 356 mg/L, respectively. Comparing all the results for total solids (TS) in the samples for dry and wet season with that of maximum permissible limit of WHO for drinking water (1500 mg/L), the result showed that TDS were within the recommended values (Table 1 and 2). The concentration of TDS obtained in Ajilosun, Odo- Ado and Adebayo showed increase in TDS value during dry and wet season. These might be due to the activities around the mechanic workshop as well as leachate run off during the wet season. Low value of conductivity, salinity and TDS in water reflect the freshness of the water (Oyakilome *et al*., 2012).

Table 1: Physico-chemical parameters of underground well water samples for dry season

Sample Code	pH	Temp (^{0}C)	Conductivity (µms/cm)	DO (mg/L)	COD mg/L	Turbidity (NTU)	Sulphate (mg/L)	Total hardness (mg/L)	SS (mg/L)	TS (mg/L)	TDS (mg/L)	Chloride (mg/L)	Alkalinity (mg/L)	Acidity (mg/L)
AJD	6.20	27.1	279	4.08	12.2	20.2	5.94	160	62.0	300	200	140	14.2	0.20
OAD	6.87	26.0	434	5.19	10.1	14.2	8.34	200	80.0	350	210	128	18.6	0.16
DAD	5.92	28.0	317	3.98	13.2	25.2	6.09	280	100	360	300	142	12.1	0.20
ADD	6.02	26.0	440	5.01	10.7	18.4	9.05	260	68.1	290	240	78.1	18.3	0.22
CSD	7.00	21.1	380	5.26	9.07	12.5	7.63	220	76.0	310	260	130	20.2	0.10
Mean	6.25	26.8	368	4.57	11.5	19.5	7.36	225	77.5	325	238	122	15.8	0.20
SD	0.42	0.97	81.8	0.62	1.40	4.55	1.58	55.1	16.7	35.1	45.0	29.9	3.18	0.03
CV%	6.72	3.62	22.2	13.6	12.2	23.3	21.5	24.5	21.5	10.8	18.9	18.8	20.1	15.0

Table 2: Physico-chemical parameters of underground well water samples for rainy season

Sample Code	pH	Temp (^{0}C)	Conductivity (µms/cm)	DO (mg/L)	COD (mg/L)	Turbidity (NTU)	Sulphate (mg/L)	Total hardness (mg/L)	SS (mg/L)	TS (mg/L)	TDS (mg/L)	Chloride (mg/L)	Alkalinity (mg/L)	Acidity (mg/L)
AJR	7.89	24.0	456	4.51	12.8	22.5	8.92	360	142	480	356	177	24.5	0.28
OAR	7.59	21.0	360	4.72	10.9	12.8	6.62	300	82	400	340	157	26.5	0.26
DAR	7.00	22.0	289	4.29	13.2	28.2	13.2	320	80	460	300	149	14.6	0.25
ADR	7.29	23.1	232	4.05	14.4	30.4	5.17	300	100	420	320	208	15.2	0.25
CSR	7.50	20.0	324	5.11	9.9	11.4	7.49	298	64	400	298	128	24.5	0.20
Mean	7.44	22.5	334	4.39	12.8	23.5	8.48	320	101	360	354	173	20.2	0.26
SD	0.38	1.30	96.6	0.28	1.46	7.86	3.51	28.3	28.8	177	49.9	26.3	6.18	0.01
CV%	5.10	5.78	28.9	6.38	11.4	33.4	41.4	8.84	28.5	49.2	14.1	15.2	30.6	3.85

Table 3: Concentration (mg/L) of heavy metals in underground well water samples collected during the dry season

Sample Location	Zn	Cr	Pb	Cd	Cu	Fe
AJD	1.0747	0.0003	0.0021	0.0016	1.0836	0.1862
OAD	1.3510	0.0008	0.0016	0.0047	1.2537	0.3671
DAD	0.8095	0.0006	0.0031	0.0118	1.1639	0.2164
ADD	1.1572	0.0005	0.0019	0.0068	1.3226	0.3475
CSD	0.9114	0.0004	0.0012	0.0006	1.1844	0.3177
Mean	1.0981	0.0006	0.0022	0.0063	0.2060	0.0913
SD	0.2246	0.0002	0.0006	0.0043	0.1040	0.0913
CV%	21.0	33.3	27.3	68.3	8.62	33.0

Table 4: Concentration (mg/L) of heavy metals in underground well water samples collected during the rainy season

Sample Location	Zn	Cr	Pb	Cd	Cu	Fe
AJR	1.3921	0.0003	0.0028	0.0111	1.2619	0.3117
OAR	1.1825	0.0002	0.0017	0.0062	1.0976	0.3066
DAR	2.0512	0.0009	0.0036	0.0136	1.8552	0.4623
ADR	1.0293	0.0003	0.0014	0.0057	0.9099	0.2893
CSR	0.7492	0.0005	0.0021	0.0026	1.1329	0.3826
Mean	1.4138	0.0043	0.0024	0.0092	1.2812	0.3425
SD	0.4502	0.0003	0.0010	0.0038	0.4088	0.0805
CV%	31.8	6.98	41.7	41.3	31.9	23.5

The turbidity concentration in the samples ranged from 14.2 - 25.2 NTU in dry season and 12.8 - 30.4 NTU in wet season. The results showed high turbidity when compared with maximum permissible level of NAFDAC, SON, and WHO (5.0 NTU).

The alkalinity ranged from 12.1 – 26.5 mg/L in all the water samples for both season. Alkalinity is a measure of the ability of a given sample of water to neutralize an acid to an indicator end point. Species responsible for alkalinity levels in water are bicarbonate, carbonate and hydroxyl of Ca, K, Mg and Na. Odo – Ado samples showed greater concentration in both season when compared with other water samples. The acidity ranged between 0.16 – 0.22 mg/L with an average value of 0.20 ± 0.03 for dry seasons while wet season ranged from 0.25 – 0.28 mg/L with an average value of 0.26 ± 0.01. Acidity in water could be due to the presence of organic acid, hydrolyzing salt of Fe^{2+} or $Al_2 (SO_4)_3$.

The Chloride levels in all the samples ranged from 78 – 140 mg/L in dry season and 149 - 208 mg/L in wet season. All the samples showed concentration below maximum permissible level in drinking water for acidity (EU, 1998; EPA, 2001; USEPA, 2002; WHO, 2008). The total hardness showed high level of dissolve calcium and magnesium carbonate. The results for both seasons showed that all the samples were above NAFDAC maximum allowed limit (100 mg/L). One of several arbitrary classifications of water by hardness include, Soft up to 50mg/L $CaCO_3$, Moderately salt 51 – 100mg/L $CaCO_3$, Slightly hard 101 – 150 mg/L $CaCO_3$, Moderately hard 151 -250 mg/L $CaCO_3$, hard 251 – 350 mg/L $CaCO_3$, Excessively hard over 350 mg/L $CaCO_3$ (EPA, 2001). The results of analysis showed that water samples collected during the dry season were moderately hard while the wet season were hard.

Statistical results showed that most of the pysico-chemical parameters for both dry and wet seasons are significantly different except for pH, temperature, dissolved oxygen and acidity. On pair wise comparison using linear correlation r_{xy} at $P_{0.05}$ n-2=12, there were significant different in the concentration of pysico-chemical parameters and the control samples for both seasons.

Heavy metal concentration in the water samples

Table 3 and 4 showed heavy metal concentration in water samples from hand dug well collected from Ajilosun, Odo – Ado, Dallimore and Adebayo at auto mechanic workshop during the dry and wet season, respectively. Zn, Cr, Pb, Cd, Cu and Fe were analyzed from the water samples. The concentration of Zn ranged from 0.8095 – 1.1572 mg/L, Cr 0.0003 – 0.0008 mg/L, Pb 0.0016 – 0.0031 mg/L, Cd 0.0016 – 0.0118 mg/L, Cu 1.0836 – 1.3226 mg/L and Fe 0.1862 – 0.3671 mg/L in dry season. Dallimore and Odo- Ado samples during the dry season exceeds the acceptable level 0.003 mg/L as stipulated by WHO for maximum permissible levels for Cd in drinking water. The concentration of Zn, Cr, Pb, Cd, Cu, and Fe in the samples during the rainy season ranged from 1.0293 - 2.0512, 0.0002 - 0.0009, 0.0014 - 0.0036, 0.0057 - 0.0136, 0.9099 - 1.8552mg/L and 0.2893 - 0.46623mg/L, respectively. From the results obtained, it could be observed that the metal concentration varies from one sampling site to another, this could be attributed to the geological distribution of mineral that varies from one location to another, the activities on the mechanic workshop, age of workshop e.t.c. Comparing the result obtained during the rainy season with highest desirable standard in Zn and Cu for drinking water by WHO (1996), all the samples showed values higher than the standard for Zn and Cu in drinking water. On pair wise comparison using linear correlation r_{xy} at $P_{0.05}$ n-2=4, there were significant difference in the concentration of heavy metals and the control samples for both seasons.

Conclusion

The turbidity, suspended solids (SS) and total dissolved solids (TDS) were high when compared to the recommended standards for drinking water, and thus constituting a serious hazard to public health of the people in the workshop and environs. The samples met the WHO (2004) guideline values set for Cr, Pb and Fe for highest desirable level 0.05, 0.01 and 1mg/L for both seasons. Zn, Cu and Cd were a bit higher than highest desirable level 0.01, 0.5 and 0.003 mg/L for drinking water. Therefore, activities at the auto-mechanic workshop are partially contributing to the levels of heavy metals in the well. The study therefore recommend (i) Proper disposal of wastes generated from the mechanic workshop (ii) Activities carried out at the workshop should be done with high level of sustainability (iii) Mechanic workshops should be cited in environmental non-sensitive areas and residential land uses should be discouraged from migrating to such areas (iv) Strict compliance to regulatory laws in waste released from these workshop into the environment and the enforcement of other environmental protection regulations.

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